Application

for

United States Patent

To all whom it may concern:

Be it known that, Randall Malterer

has invented certain new and useful improvements in

CHILL BLOCKS AND METHODS FOR MANUFACTURING CHILL BLOCKS

of which the following is a description:

CHILL BLOCKS AND METHODS FOR MANUFACTURING CHILL BLOCKS

FIELD OF THE INVENTION

[0001] The present invention relates generally to casting devices. More particularly, the present invention is directed to chill blocks that are manufactured from two metals.

BACKGROUND OF THE INVENTION

[0002] In die casting, chill blocks are devices utilized in molds. Typically, two tools are utilized to form a mold that will be employed to manufacture a complete object. Each of the tool devices has a cavity that defines the shape of a portion of the object to be cast, and when arranged together define the entire shape of the object to be cast. Each of the tools has a tool passageway leading from the die cavity to the chill blocks.

[0003] Chill blocks are positioned in each of the tools and when the chill blocks are arranged together, the chill blocks form a chill block passageway. The tool passageway provided in each tool allows gas in the die cavity to flow from the die cavity to the chill block passageway, when molten metal is injected into a die cavity to form an object.

[0004] The gas forced into the passageway of a die cavity enters the chill block passageway and escapes when it reaches the end of the chill block passageway. After a die cavity has been filled and gas present in the mold cavity has been allowed to escape, any metal overflow from a die cavity travels

into the chill block passageway. The molten metal may solidify in the chill block passageway.

[0005] However, if the molten metal does not solidify while in the chill block passageway the molten metal may escape from an end of the chill block passageway.

[0006] Some chill blocks known in the art experience problems with the retention of heat. For example, there are two-part chill blocks that involve a steel part coupled to a copper part. Often, a thermal grease is placed between the two parts to facilitate heat exchange between the steel part and the copper part. Heat retention is associated with the use of two-part steel and copper chill blocks. When chill blocks retain heat, the molten metal may not solidify at a rate to prevent it from escaping the chill blocks.

[0007] After the molten metal has solidified in the passageway formed between the pair of chill blocks, each of the chill blocks may be removed from the metal that solidified between them. The surface of a chill block that comes in contact with the overflow metal is referred to as the parting surface of the chill block or the chill block face. Typically, the parting surface has a jagged surface. One conventional type of chill block is made entirely from copper. However, users of copper chill blocks have found that copper degrades rapidly when it comes in contact with aluminum. Aluminum is commonly utilized in die casting to form objects. As a result, copper chill blocks are replaced often during the manufacturing of aluminum objects.

[0008] Accordingly, it is desirable to provide chill blocks that avoid the retention of heat and allow molten metal to solidify while in the

passageway formed by a pair chill blocks. It is also desirable to provide chill blocks that are durable, and allow for efficient manufacturing of objects by die casting methods.

SUMMARY OF THE INVENTION

[0009] The foregoing needs are met, to a great extent, by the present invention, wherein in one aspect an apparatus is provided that in some embodiments allows molten metal to solidify in the passageway formed by a pair of chill blocks, and that provides for efficient manufacturing of objects by die casting methods.

[0010] In accordance with one embodiment of the present invention, a method of manufacturing a chill block is provided, comprising forming a first surface of a chill block from a first material and bonding a second material to the first surface. The first material may be steel and the second material may be copper or a copper alloy. The first material is preferably applied at a thickness of less than about 0.5 inches.

[0011] In accordance with another embodiment of the present invention, a third material may be bonded to a side of the second material that is not in contact with the first material. Any of the surfaces may then be optionally machined. The first surface and/or the chill block may be formed in a ceramic mold. The third material may be steel and preferably chosen from the group consisting of ANSI H13, ANSI A2, and ANSI S7.

[0012] In accordance with yet another embodiment of the present invention, a method of manufacturing a chill block is provided, comprising using a rapid solidification process to spray a first material to form a first

layer, and then using the rapid solidification process to spray a second material onto a surface of the first layer. The second material may be copper or a copper alloy.

[0013] In accordance with yet another embodiment of the present invention, chill block is provided, comprising a base having a top surface and a bottom surface of a first material, and a first layer of a second material bonded to the top surface of the base.

[0014] In accordance with yet another embodiment of the present invention, a tool device for use with a die casting process for shaping and solidifying molten metal into a shaped object is provided, comprising a shaping means for forming the shape of an object and a chilling means for solidifying metal that exits the shaping means. The chilling means may comprise a layer of a first material and a layer of a second material that are bonded together. The tool may also include a metal inlet means for allowing metal to flow into the tool, an overflow means between the shaping means and the chilling means, and/or a second chilling means arranged with the first chilling means to form a chill block passageway.

[0015] There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

[0016] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

[0017] As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a top view of a tool incorporating a chill block in accordance with an embodiment of the present invention.

[0019] FIG. 2 is perspective view of a chill block in accordance with an embodiment of the present invention.

[0020] FIG 3 is a flow chart illustrating a method of manufacturing chill blocks in accordance with the present invention.

[0021] FIG. 4 illustrates a pair of chill blocks in accordance with the present invention.

DETAILED DESCRIPTION

[0022] The invention will now be described with reference to the drawing figures, in which like reference numerals refer to like parts throughout. An embodiment, in accordance with the present invention, provides a chill block made from copper metal that is bonded to a layer of tool steel.

[0023] The tool steel layer can have a thickness of less then about 0.5 inches. In some embodiments, preferably, the tool steel layer has a thickness ranging from about 0.060 to about 0.090 inches and is present on the parting surface of the chill block or chill block face. A tool steel layer may also be bonded on a portion of the sides of the chill blocks and/or the bottom of the chill block. Chill blocks in accordance with the present invention allow molten metal to solidify in the passageway formed by a pair of chill blocks, and provide for efficient manufacturing of objects by die casting methods.

[0024] A tool 10 incorporating chill blocks 12, 14 in accordance with the present invention is illustrated in FIG. 1. The tool 10 includes chill blocks 12, 14 positioned within a tool. Although only one tool 10 is shown in FIG. 1, typically two tools 10 are utilized to form a complete mold for forming an object via die casting. Die cavities 16, 18, 20, 22, corresponding to the shape of objects to be cast are formed in the tool 10. The die cavities 16, 18, 20, 22 shown in FIG. 1 correspond to one portion of the mold that will form the

resulting object. The other portion of the mold will be present in die cavities of a tool similar to tool 10, and when tool 10 and a corresponding tool are placed adjacent one another, a complete mold for the objects to be cast is formed.

[0025] A tool inlet port 24 is provided in the tool 10 that allows the injection of a molten metal into the tool 10. A channel 26 is coupled to the tool inlet port 24 that allows molten metal injected into the tool 10 to flow into the die cavities 16, 18, 20, 22 via die cavity inlet ports 28, 30, 32, 34, 36, 38, 40, 42.

[0026] Die cavity outlet ports 44, 46, 48, 50, 52, 54, 56, 58 are provided in the tool 10 that allow molten metal to exit the die cavities 16, 18, 20, 22. Overflow passageways 60, 61, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82 are coupled to the die cavity outlet ports 44, 46, 48, 50, 52, 54, 56, 58 and allow any overflow metal exiting the die cavities 16, 18, 20, 22 to reach the chill blocks 12, 14. Each of the chill blocks includes a parting surface/chill face 84, 86 that has a ribbed or jagged surface. Chill outlet ports 83, 85 are provided that allow a gas, for example, air, to exit the tool 10.

[0027] Shown in FIG. 2 is a preferred embodiment of a chill block 12 in accordance with the present invention. Molten metal enters chill block 12 from an overflow passageway 60, 61, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82 via a chill block inlet port 100. That is, the chill block inlet port 100 receives overflow metal from a die cavity 16, 18, 20, 22. The base of the chill block 88 (chill block base) is made from a material, for example, copper, or a

metallic composition that includes copper, for example, beryllium copper, and is the foundation to which the tool steel is layered upon.

[0028] A layer, preferably having a thickness of less then about 0.5 inches and more preferably ranging from about 0.06 to about 0.09 inches, of a tool steel is applied, for example, by a spraying technique, such as a rapid solidification process developed at the Idaho National Engineering and Environmental Laboratory, to the parting line surface 90 of the chill block 12, and to a portion 92, 94 or to all of the sides 96, 98 of the chill block 12. The rapid solidification process is a spraying technique to harden the tool steel. The rapid solidification process is described in U.S. Patent Nos. 5,718,863 and 6,074,194, which are incorporated by reference. The tool steel utilized is steel that is stronger than the material forming the chill block base 88.

[0029] In a preferred embodiment of the present invention, the tool steel utilized may be any ANSI (American National Standards Institute) or International Standards Organization(s) defined tool steel. Examples of these tool steels include, but are not limited to, ANSI H13, ANSI A2, and ANSI S7. According to other preferred embodiments, other materials having, for example, materials having a surface hardness of at least 30 Rockwell "C" scale (Rc) may be utilized, and preferably materials having a surface hardness ranging from about 30 to about 70 Rc may be utilized. More preferably, materials having a surface hardness ranging from 30 to about 65 Rc are utilized. According to some embodiments, however, steel having a surface hardness greater than 65 Rc may also be utilized.

[0030] An exemplary composition of ANSI H13 tool steel includes, by percentage weight, about 0.4 carbon (C), about 0.4 manganese (Mn), about 1.00 Silicon (Si), about 5.25 chromium (Cr), about 1.35 molybdenum (Mo), and about 1.00 vanadium (V). The remainder of the exemplary composition of ANSI H13 is iron or primarily iron. The ANSI H13 tool steel is characterized by its toughness and ability to resist thermal fatigue cracking that may occur as a result of cyclic heating and cooling cycles that result from the repeated use of a tool to form an object from die casting methods.

[0031] An exemplary composition of ANSI A2 tool steel, includes, by percentage weight, 1.00 carbon (C), 0.75 manganese (Mn), 0.30 Silicon (Si), 5.00 chromium (Cr), 1.00 molybdenum (Mo), and 0.25 vanadium (V). The remainder of the exemplary composition of A2 is iron or primarily iron. The ANSI A2 tool steel is characterized by its toughness and strength.

[0032] An exemplary composition of ANSI S7 tool steel, includes, by percentage weight 0.50 carbon (C), 0.75 manganese (Mn), 0.25 Silicon (Si), 3.25 chromium (Cr), and 1.40 molybdenum (Mo). The remainder of the exemplary composition of S7 is iron or primarily iron. The ANSI A2 tool steel is characterized by its toughness and wear resistance properties.

[0033] In a second embodiment of the present invention, the chill block base 88 is made from a material, for example, copper or a metallic mixture including copper, for example, beryllium copper. A layer having a thickness, of less than about 0.5 inches and preferably ranging from about 0.060 to about 0.090 inches, of a tool steel is applied, for example, by a spraying technique, such as the rapid solidification process developed at the

Idaho National Engineering and Environmental Laboratory, to the parting line surface/chill face 90 of the chill block base 88 and around a portion 92, 94 of the sides 96, 98 of the chill block 12. In addition, a layer of tool steel is present on the bottom of the chill block base 88.

[0034] In a third embodiment of the present invention, a layer of tool steel is not present on any portion of the sides 96, 98 of the chill block 12.

[0035] FIG. 3 is a flow chart illustrating a preferred embodiment of a new method 102 for manufacturing a chill block. The process of manufacturing a chill block in accordance with the preferred embodiment of the present invention involves applying a layer of a first material, for example tool steel, having a thickness of less than about 0.5 inches and preferably ranging from about 0.060 to about 0.090 inches, on an inside surface of a mold that is a negative of the chill block being formed 104.

[0036] Preferably, a rapid solidification process is utilized to apply the tool steel. A second material, for example, copper or beryllium copper is added on top of the first material, preferably, by the rapid solidification process 106. The tool steel is porous. When the copper metal is added on top of the tool steel, the copper metal fills the pores formed in the tool steel. Thus, in accordance with the present invention, when the copper metal solidifies, the copper metal bonds, for example, mechanically and/or chemically, to the tool steel. The chill block 12 is then machined to the size required for installation in the desired tool 108.

[0037] According to a second preferred method for forming a chill block according to the present invention, after the second material, for

example, copper or beryllium copper is added on top of the first material 106, the chill block is machined such that is smaller than a predetermined final size for the chill block 108a. A third layer of a material, for example, a tool steel, is added on top of the second layer of material that is not in contact with the inside surface of the mold 110, and the chill block may be larger than the desired size for the chill block. In accordance with the present invention, the copper or beryllium copper bonds, for example, mechanically and/or chemically, to the tool steel. The chill block is then machined, a second time, to the size required for installation into a tool 112.

[0038] In an exemplary embodiment, a chill block resulting from the second method of forming a chill block has a first layer and a third layer that are formed from tool steel, and the second layer is copper or copper beryllium. Accordingly, the external surfaces, top, bottom and sides, of the chill block are tool steel, and the external surfaces encapsulate the copper layer or layers. Accordingly, the copper layer or layers of the chill block is protected when being handled, installed, and/or removed from a tool.

[0039] Shown in FIG. 4 is a side view of two chill blocks 12, 14 placed in a mold 114. In a preferred embodiment of the present invention, a chill block 12 is placed in the tool 116 that forms, for example the top portion of the mold (top tool device). The chill block 12 placed in the top tool device 116 is referred to as the cover chill block. In a preferred embodiment of the present invention, chill block 144 is placed in the in the tool 118 that forms, for example the bottom portion of mold (bottom tool device). The chill block 14 placed in the bottom tool device 118 is referred to as the ejector chill block.

[0040] As shown in FIG. 4, the chill blocks 12, 14 are assembled, such that a chill block passageway 120 is formed between the pair of chill blocks 12, 14. In an exemplary embodiment of the present invention, a vacuum 122 is coupled to the chill block outlet port 124 via a conduit 126 to remove gas that enters the chill block passageway 120.

[0041] During die casting, molten metal is injected into the tool inlet port 24. The molten metal flows into the channel 26, and into the die cavity inlet ports 28, 30, 40, 42 that are open to the channel 24. As the molten metal flows into the die cavities 16, 18, 20, 22 gas, for example, air, that is present in a die cavity 16, 18, 20, 22 flows out of a die cavity 16, 18, 20, 22 via the die cavity outlet ports 44, 46, 48, 50, 52, 54, 56, 58 and into overflow passageways 60, 61 and 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82. From the overflow passageways, the gas moves into one or more chill block passageways 118 via the chill block inlet port 100 and out from chill block passageway 118 via a chill block outlet port 83, 85, 124.

[0042] The application of, for example, copper or beryllium copper to the chill block base, provides for a heat transfer rate that allows molten metal that flows into a chill block passageway 118 to solidify in the chill block passageway 116. Accordingly, molten metal may be prevented from exiting the tool via the chill block outlet port 83, 85, 124.

[0043] After any overflow molten metal has solidified in the chill block passageway 118, the top and bottom tool devices 114, 116, including the cover and ejector chill blocks 12, 14, are separated and the objects formed in the die cavities are removed.

[0044] Aluminum is a common metal utilized in die casting to form objects. The application of a hardened tool steel to the chill block parting surface toughens and strengthens chill block parting surfaces, and allows the chill blocks, in accordance with the present invention, to resist the degrading properties of molten aluminum for a period of time.

[0045] Further, the chill blocks, in accordance with the present invention, involve a steel layer that is bonded to a copper metal layer. Accordingly, the need mechanically couple the a steel part to a copper part, as required when utilizing the prior art two-part steel and copper chill blocks is eliminated. Also, the need for a thermal grease to facilitate the transfer of heat between the steel part and the copper part is obviated. Moreover, the thickness of the steel layer is thinner than a steel layer of a conventional two-part steel and copper chill block of the prior art.

[0046] The many features and advantages of the invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the true spirit and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.